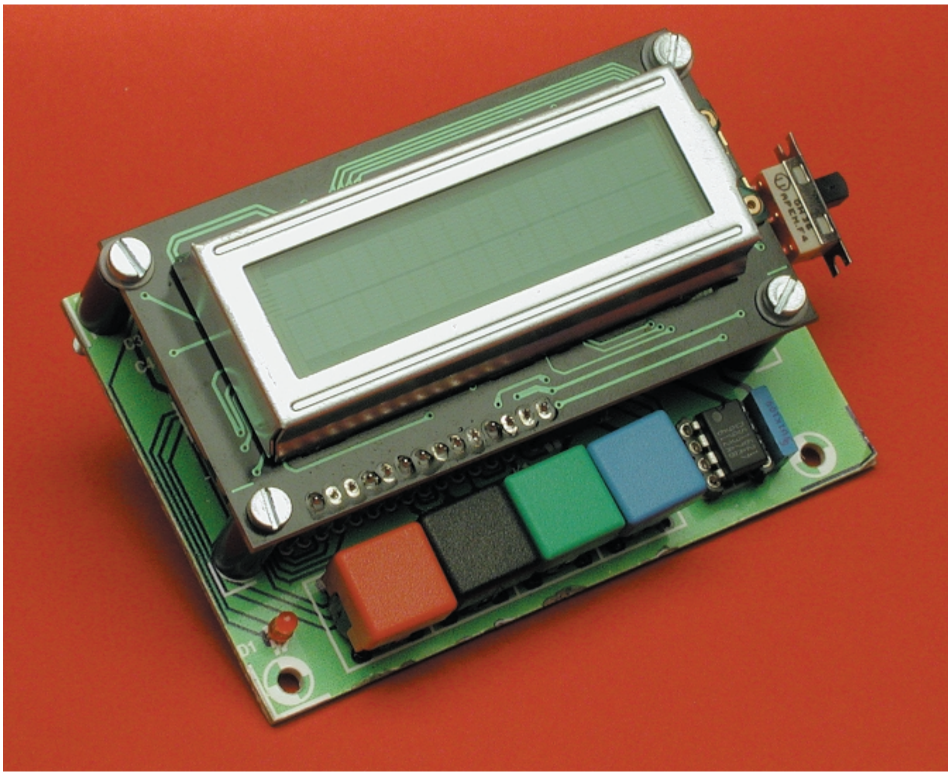
DS1621 Programmer

sensor operation without a PC

Design by A. Tüchter

The Dallas Semiconductor DS1621 thermometer/thermostat IC can be programmed and read via a two-wire bus. Instead of using a full-blown PC for this purpose, you can use this handy, battery-operated programmer.



The Dallas Semiconductor DS1621 is a general-purpose thermometer with thermostat functions. The features of this device have already been fully described in the article 'Temperature measurements with the DS1621' in the March 2000 issue of *Elektor Electronics*. If you missed this issue, you can find the necessary information on the device data sheet, which you can obtain from www.dalsemi.com/datasheets/pdfs/1621.pdf. Here we will only repeat the essentials. All read and write operations for both the thermometer and the thermostat take place via an I^{2}C bus. Dallas Semiconductor also provides a (free) program for this at ftp://ftp.dalsemi.com/pub/thermal/ds1621k.zip, although this can only be used with the Windows operating system. This may be perfectly OK for experimental purposes, but in everyday life it may be quite cumbersome to use a PC every time you want to read the configuration register, configure the thermostat set-points, or just start a measurement sequence without slope time. Consequently, the author has developed a programmer that is small, inexpensive and above all battery-operated. This device, which is half the size of a standard Eurocard, is based on an Atmel microcontroller and can access all functions of the DS1621. This means that you don't need Windows or a mains supply, and you don't have to lug around a laptop.

The programmer allows you to program a DS12621 that is integrated into an application circuit without switching off the circuit or removing the IC from the circuit. Its operation has been kept simple, but it still offers a wide range of features. Thanks to its design, the programmer can be used not only for programming the DS1621, but also as a complete data logger if it is fitted with its own DS1621. In the latter case, the thermometer IC can either be attached directly to the board or connected remotely via an adapter cable.

A microcontroller and four switches

The schematic diagram in **Figure 1** shows little more than a microcontroller with a power supply, power-

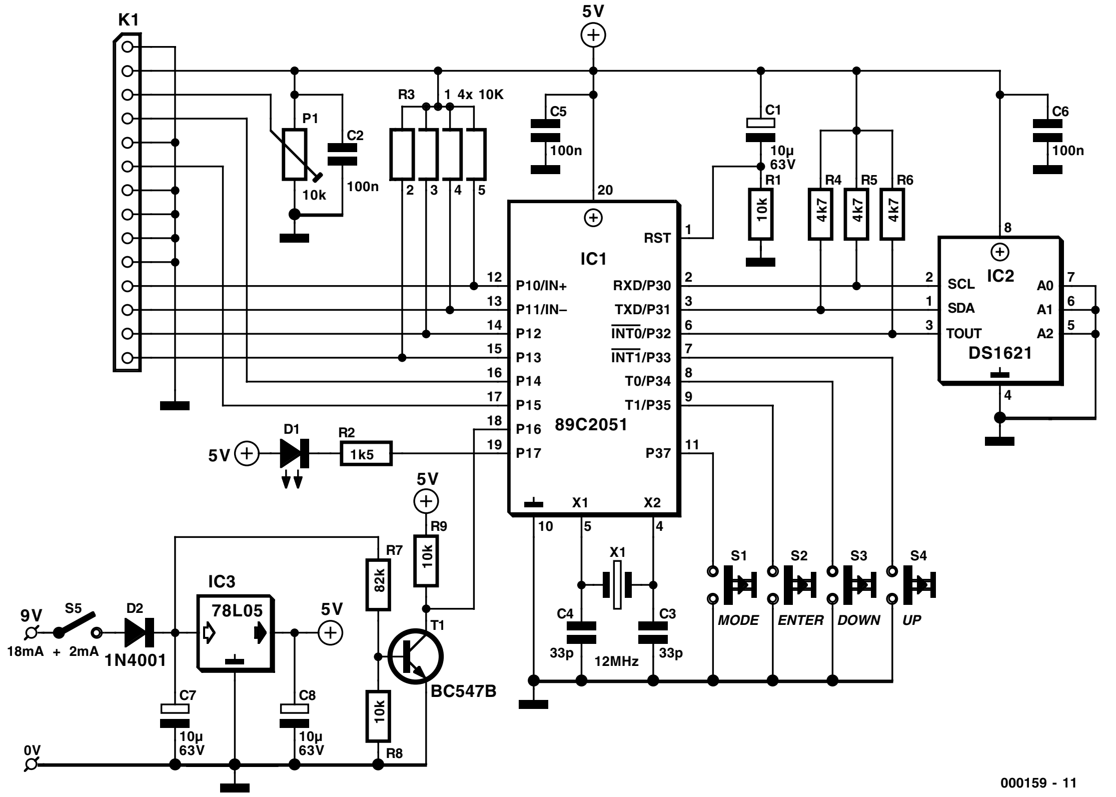


Figure 1. The microcontroller, which reads and programs the sensor IC and drives an LCD module, is controlled by four pushbuttons.

up network, crystal and four pushbutton switches. We'll have a look at the various DS1621 options and adapter cables later on, but first let's look at the controller circuit.

The AT89C2051 microcontroller drives the LCD module via connector K1, evaluates the four pushbuttons S1–S4 and communicates with the DS1621. The power-up network C1–R1 ensures that the microcontroller starts up reliably. The clock is generated by X1, C3 and C4. The controller is connected to a DS1621 (IC2) via ports P3.0–P3.2 and a socket. These three leads are held High by the three pull-up resistors R4-R6. The I^{2}C bus is formed by P3.0 (SCL) and P3.1 (SDA), while P3.1 only serves to receive a notification whenever the temperature rises above or drops below the preset thermostat thresholds during a measurement. C6 suppresses noise impulses on the DS1621 supply line.

The Error LED (D1) is driven via port P1.7, with resistor R2 limiting the current to 2 mA since a low-current LED is used here. Port P1.6 monitors the battery voltage. If the battery voltage (attenuated by the voltage divider R7-R8) is high enough, T1 conducts and a Low level is present at P1.6. As the capacity of the battery becomes exhausted, the input voltage drops and T1 blocks, which causes a High level to be applied to P1.6 via R9.

Only four pushbutton switches (S1-S4) are used to operate the programmer. These are connected to ports P3.3–P3.7. External pull-up resistors are not necessary, since the ports are pulled High internally. The LCD module is connected to the controller via ports P1.0-P1.5. It works in 4-bit mode in order to save port connections. The four data lines (D4–D7 in the LCD module) are pulled High by resistor array R3, while the unused data lines and the R/W control line are tied to ground. The display contrast can be adjusted using trimpot P1.

Power is supplied to the programmer by a 9-volt battery. Voltage regulator IC3 provides a stable +5 V supply from the battery voltage. The voltage for the battery test is tapped off after the on/off switch (S5) and reverse-polarity protection diode (D1), ahead of the regulator. The current consumption is around 18 mA, plus 2 mA for the LED (when it is on).

Connection options

In order to keep the programmer as general-purpose as possible, there are several options for connecting the sensor. The simplest of these is unquestionably inserting the DS1621 directly into the IC2 socket on the circuit board, as shown in **Figure 1**.

However, this socket can also accept a second socket as a plug (as long as the latter has thin, turned pins!), to which a cable with five leads has been soldered as shown in **Figure 2a**. A second socket is connected to the far end of this cable, which may be up to 4 m long. This socket could for example be mounted on a small piece of prototyping board. The connections between the ground lead (pin 4) and the address inputs (pins 5-7) should be made at this socket. In essence, this option amounts to an extension of the connections on the printed circuit board.

The option shown in **Figure 2b** is different. Here the adapter cable connects the programmer to an application circuit, which can be built on the small, detachable section of the printed circuit board. Only the I^{2}C bus and the ground lead are extended in this case, while the DS1621 receives its operating voltage via its own separate voltage regulator (IC5). The output of the DS1621 drives its own Error LED (D3). The IC address is set to

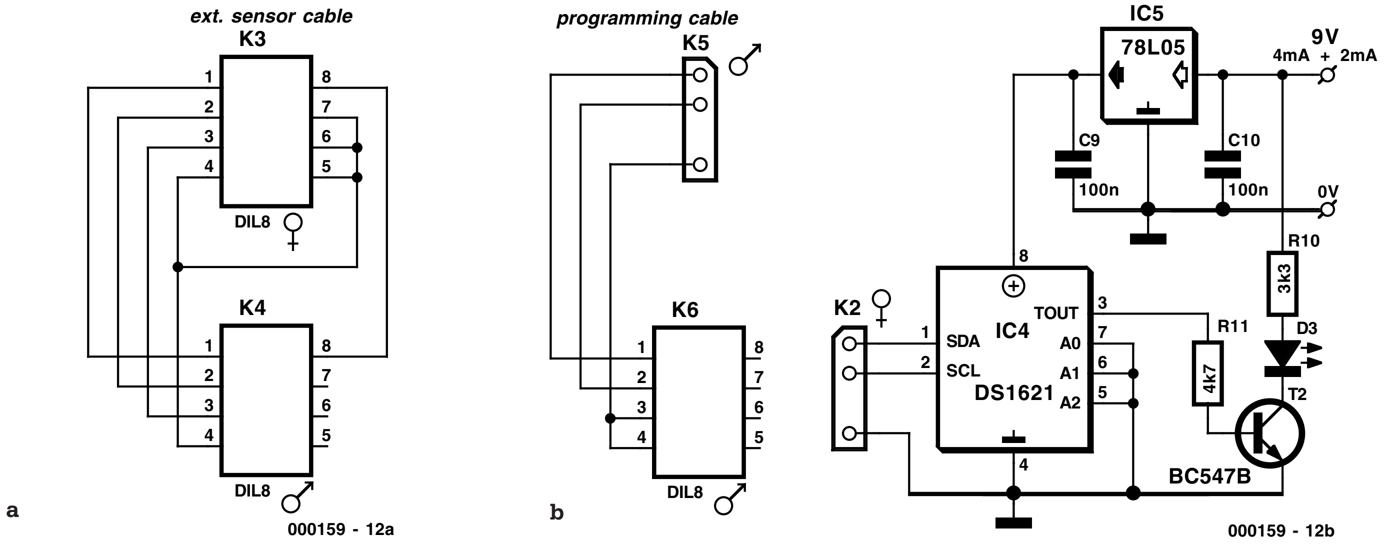


Figure 2. If the sensor is not mounted on the main circuit board, it can be connected via an external sensor cable (a). Alternatively, the sensor can be programmed in an application circuit. This requires a programming cable as shown in (b).

zero in this case as well. Since the IC output cannot be polled, pin 3 of the socket must be connected to ground. A four-pin SIL plug strip is adequate for use at the other end of the cable, with the unused pin (pin 3) broken off. If you solder pin 3 of the matching socket strip closed, it will not be possible to insert the plug the wrong way around.

Operation

The programmer must be connected to a DS1621 before being switched on. After it has been switched on, or after the Enter button (S2) has been pressed, the message *DS1621 – Programmer* appears on the display. After a short delay, communication with the DS1621 is tested. It is important to note that the programmer only works with device address 0. If communication is faulty, *Chip <ERROR> push –Enter–* is displayed and LED D1 blinks. This will always occur if no connection to a DS1621 takes place or the connection is faulty. If this happens, verify the DS1621 address and check the communications link to the sensor. If the connection is successful, the sensor is reinitialised. In this case, the display shows *Chip Testing!*. The TH and TL registers are read, as well as the Config register, and then a temperature conversion is started and read. The programmer reports the successful transfer of all data with the message *Chip <<OK>>*.

The sensor is next configured for continuous measurements and started. If the DS1621 is integrated into an application circuit, the programmer can now be disconnected from the circuit if it is not necessary to make any

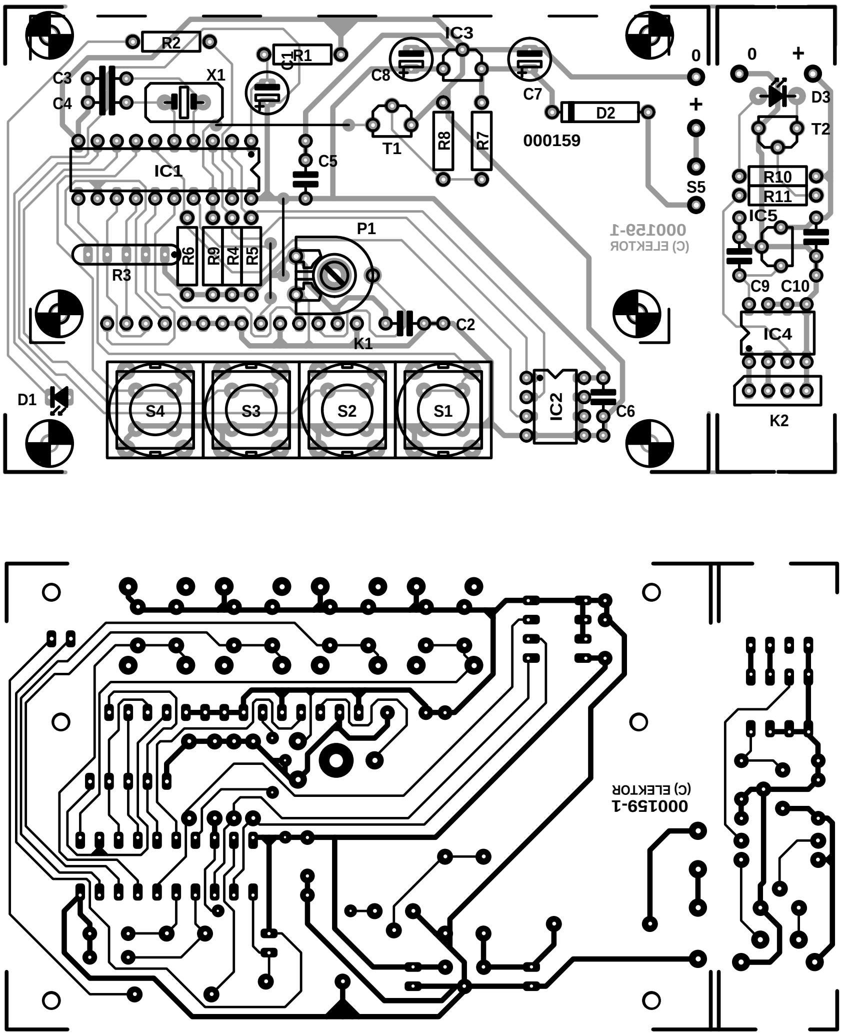


Figure 3. The relatively straightforward printed circuit board for the DS1621 programmer, with mounting holes for the LCD module and a sensor circuit board that can be cut off before the board is assembled.

changes to the settings.

Following the chip test, you reach the menu with the options *Thermometer, TH-Register, TL-Register* and *Output Polarity*. The MODE button (S1) can be used to select the desired menu item, and the selected function can be started by pressing the ENTER button.

Thermometer

In this mode, the programmer operates as a sort of data logger. Here the manner in which the DS1621 is connected does not matter. The first line of the display shows the currently measured temperature. This value is periodically updated. The second line of the display shows the absolute extreme values of the temperature, with the lower extreme on the left and the upper extreme on the right.

In addition to these values, the behaviour with respect to the hysteresis range is also displayed. If the current temperature lies below the threshold value, two dashes are displayed (– –). If the temperature rises to a level equal to or greater than the value in the TH register, *TH* appears in the display. Similarly, if the temperature drops to a level equal to or less than the value in the TL register, *TL* appears in the display. The hysteresis settings can thus be verified. LED D1 or D3, respectively, is on when the I/O output of the sensor is active. This allows the switching behaviour of the DS1621 to be simulated. The thermometer mode can be exited at any time by pressing the ENTER button.

TH and TL registers

This menu item can be used to check or modify the settings of the TH and TL registers

Parts and software via Readers Services and the WWW

A blank printed circuit board for the DS1621 programmer is available from Readers Services under order number **000159-1**. The diskette (order number **000159-11**) contains the source code and a hex file for the controller program. The circuit board layout and both software files can also be downloaded free of charge from the *Elektor Electronics* Internet site at http://www.elektor-electronics.co.uk. If you do not want to be bothered with programming the controller, you can obtain a ready-programmed device from Readers Services under order number **000159-41**.

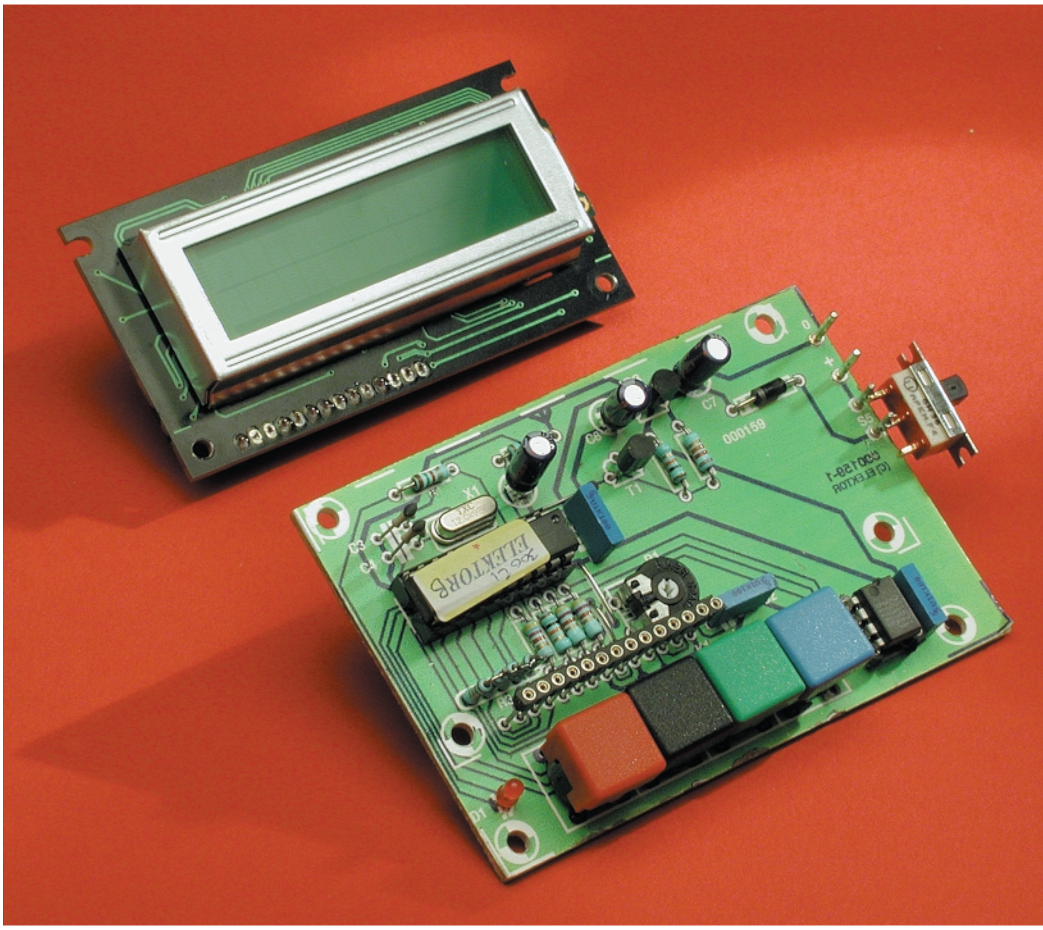
COMPONENTS LIST

Resistors:
R1,R8,R9 = 10kΩ
R2 = 1kΩ5
R3 = 10kΩ 4-way·SIL array
R4,R5,R6,R11 = 4kΩ7
R7 = 82kΩ
P1 = 10kΩ preset

Capacitors:
C1,C7,C8 = 10µF 63V radial
C2,C5,C6,C9,C10 = 100nF
C3,C4 = 33pF

Semiconductors:
D1,D3 = LED, high efficiency
D2 = 1N4001
T1,T2 = BC547B
IC1 = 89C2051-12PC (order code **000159-41**)
IC2,IC4* = DS1621 (Dallas) (Farnell # 670704) with holder
IC3,IC5* = 78L05

Miscellaneous:
K1 = LCD module, 2x16 characters (LTN211R-10, LM16A211, LM16A212)
K3,K4,K6 = 8-way IC socket with turned pins and thin connecting leads (Conrad Electronics #189600)
K2,K5 = 4- way SIL pinheader
S1-S4 = Pushbutton, 1 make contact (Multimec D6-Q or Marquardt, Conrad Electronics #706892 with cap)
S5 = slide switch, 1 changeover contact
X1 = 12 MHz quartz crystal
PC1-PC4 = solder pins
9-V PP3 battery with clip-on leads
PCB, order code **000159-1** (see Readers Services page).
Disk, all project software, order code **000159-11** (see Readers Services page).



and to verify the register flags (which indicate that he limit value has been exceeded). The register name (e.g. *TH – Register*) is shown in first line of the display, and the current register value is shown in the second line. If an exclamation point is shown following the register name (e.g. *TH – Register!*), it means that the flag bit is set, and thus that the limit value has been reached. This menu item can be exited by pressing the ENTER button, but the flags and register values remain as they were. The register value can be modified using the UP and DOWN buttons (S4 and S3). The value changes in steps of 0.5 °C over the range of –55.0 °C to +125.0 °C. If either one of the buttons is pressed, the LED is illuminated to indicate that the value has been changed, which also causes both (!) flags to be cleared. This also causes any exclamation point that may have been visible on the display to disappear. If the previous value is subsequently restored, only the two flags are reset.

Pressing ENTER exits the new programming mode and returns you to the menu.

Output polarity

This menu item can be used to check and modify the I/O output of the DS1621. If *OUTPUT = 1* is displayed, the output is active-High, which means that it goes High when a threshold value is exceeded. Correspondingly, *OUTPUT = 0* indicates that the output is active-Low. The switching behaviour of the output can be changed using the UP of DOWN button. ENTER stores the selected setting in the DS1621 and exits this menu item.

The programmer has a battery voltage monitor that is activated if the voltage is too low. The display then shows *Low Batt. – insert new batt*. The LED also blinks in this case, since this is an error condition. This error message can be eliminated by replacing the battery; it cannot be acknowledged.

Construction

The printed circuit board shown in **Figure 3** provides adequate space for the compact DS1621 programmer. You should first cut off the sensor section on the right hand side. Inserting the components into the board should not present any problems, although you may need to use a horizontal package for crystal X1 and mount C1 flat on the board, so that the LCD module will not have to be mounted too high above the board. The mounting holes match the module shown in the Components List. The K1 connections can be made using either thin wires or an inline pin connector strip with extra-long wire-wrap pins. Don't forget to adjust the display contrast (immediately after completing the assembly, naturally) using P1, via the back side of the circuit board.

Normally, it will be sufficient to solder in a standard IC socket for IC2. However, if you plan to program a large number of DS1621s, it wouldn't hurt to use a test socket (not to be confused with an expensive ZIF socket). With such a socket, the IC can be lifted out of the precision gold-plated socket pins using a wedge. This is beneficial for the service life of the socket and the mechanical symmetry of the IC pins. Unfortunately, 8-pin test sockets are not available, but a 14-pin model can be used if you cut off three pairs of pins.

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CONSTRUCTION GUIDELINES

Elektor Electronics (Publishing) does not provide **parts and components other than** PCBs, fornt panel foils and software on diskette or IC (not necessarily for all projects). Components are usually available form a number of retailers – see the adverts in the magazine.

Large and small values of components are indicated by means of one of the following prefixes :

E (exa) = 10^{18}
P (peta) = 10^{15}
T (tera) = 10^{12}
G (giga) = 10^{9}
M (mega) = 10^{6}
k (kilo) = 10^{3}
h (hecto) = 10^{2}
da (deca) = 10^{1}

a (atto) = 10^{-18}
f (femto) = 10^{-15}
p (pico) = 10^{-12}
n (nano) = 10^{-9}
μ (micro) = 10^{-6}
m (milli) = 10^{-3}
c (centi) = 10^{-2}
d (deci) = 10^{-1}

In some circuit diagrams, to avoid confusion, but contrary to IEC and BS recommandations, the value of components is given by substituting the relevant prefix for the decimal point. For example,

3k9 = 3.9 kΩ
4μ7 = 4.7 μF

Unless otherwise indicated, the tolerance of resistors is ±5% and their rating is ⅓–½ watt. The working voltage of capacitors is ≥ 50 V.

In **populating a PCB**, always start with the smallest passive components, that is, wire bridges, resistors and small capacitors; and then IC sockets, relays, electrolytic and other large capacitors, and connectors. Vulnerable semiconductors and ICS should be done last.

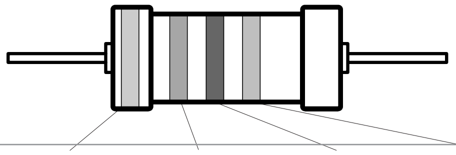
Soldering. Use a 15–30 W soldering iron with a fine tip and tin with a resin core (60/40) Insert the terminals of components in the board, bend them slightly, cut them short, and solder: wait 1–2 seconds for the tin to flow smoothly and remove the iron. Do not overheat, particularly when soldering ICS and semiconductors. Unsoldering is best done with a suction iron or special unsoldering braid.

Faultfinding. If the circuit does not work, carefully compare the populated board with the published component layout and parts list. Are all the components in the correct position? Has correct polarity been observed? Have the powerlines been reversed? Are all solder joints sound? Have any wire bridges been forgotten?

If voltage levels have been given on the circuit diagram, do those measured on the board match them – note that deviations up to ±10% from the specified values are acceptable.

Possible corrections to published projects are published from time to time in this magazine. Also, the readers letters column often contains useful comments/additions to the published projects.

The value of a resistor is indicated by a **colour code** as follows.



color	1st digit	2nd digit	mult. factor	tolerance
black	–	0	–	–
brown	1	1	×10^{1}	±1%
red	2	2	×10^{2}	±2%
orange	3	3	×10^{3}	–
yellow	4	4	×10^{4}	–
green	5	5	×10^{5}	±0,5%
blue	6	6	×10^{6}	–
violet	7	7	–	–
grey	8	8	–	–
white	9	9	–	–
gold	–	–	×10^{-1}	±5%
silver	–	–	×10^{-2}	±10%
none	–	–	–	±20%

Examples:
brown-red-brown-gold = 120 Ω, 5%